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Review on Status and Constraints of Artificial Insemination in Dairy Cattle in Developing Countries: The Case of Ethiopia

Temesgen Tadesse Yitayih[1*] Tibebu Markos Moges[2] Usman Lelo Kebeto[3]
Addis Ababa University College of Veterinary Medicine and Agriculture PO box 34, Bishoftu, Ethiopia

Abstract
Artificial insemination (AI) is the manual placement of semen in the reproductive tract of the female by a method other than natural mating which is one of a group of technologies commonly known as "assisted reproduction technologies" (ART), whereby offspring are generated by facilitating the meeting of gametes (spermatozoa and oocytes). AI is by far the most common method of breeding of intensively kept dairy cattle. In relation to the status, there is a big gap in biotechnology use in general between developed and developing countries, with Artificial insemination (AI) being the biotechnology most widely applied in developing countries as compared to other biotechnologies. In developed countries, advances in Artificial insemination have already had a major impact on livestock improvement programmes. Similarly, most developing countries express the wish to increase the utilization of Artificial insemination even though in many cases clear plans for incorporating this technology into animal genetic resource management are lacking. AI speeds up genetic progress, reduces the risk of disease transmission and expands the number of animals that can be bred from a superior parent. In Ethiopia, even though this service has been in operation for over 30 years with different levels of intensification, its efficiency has remained at a very low level due to infrastructural, managerial and financial constraints and also due to poor heat detection, improper timing of insemination and embryonic death.
Keywords: Artificial insemination, Biotechnology, Constraints, Developing countries, Ethiopia

1. Introduction

Livestock production is one of the fastest growing agricultural subsectors in developing countries; where it accounts for more than a third of agricultural GDP. It is projected soon to overtake crop production as the most important agricultural subsector in terms of added value (FAO, 2006). Many developing and transition countries have realized high economic growth in recent years. This, coupled with an increasing population, an expanding urban population and growth in personal incomes, is altering the lifestyle and purchasing patterns with respect to food products by which global food protein demand is shifting from plant proteins to animal proteins. It is projected that the demand for animal products will nearly double by 2030, and that a large proportion of this increase will be in developing countries (FAO, 2002).

The increasing demand for livestock products, termed the "Livestock Revolution", is creating opportunities for improving the welfare of millions of poor people who depend on livestock for their livelihoods and could become a key means of alleviating poverty. It has been observed that rapid growth in livestock production, in addition to providing benefits to the farmers and the animal product industry, has stimulated demand for, and increased the value of, labour, land, and non-agricultural goods and services, resulting in overall economic growth. However, increasing land degradation, global warming, erosion of animal and plant genetic resources, livestock mediated environmental pollution, severe water shortages and the threat of emerging infectious diseases pose several new challenges to sustainable animal production and food security, particularly in developing countries (FAO, 2006; OIE, 2007; World Bank, 2009).

Africa, one of the developing continents, has 16% of the world's dairy livestock but produces less than 4% of global milk production with an average cow producing only 454 litres per year compared to 5630 litres for top producing cows in the European Union (EU). This is in spite of the fact that livestock products account for 25-35% of agricultural production in Africa (USDA, 2006). This low level of milk production in Africa can be attributed to a number of constraints that include low quality dairy breeds, limitation imposed by harsh environmental conditions such as high ambient temperatures, high incidence of diseases and parasites and poor nutrition (Gefu, 1989). An equally important factor is the generally low level application of modern technology in the management of dairy cattle, particularly among the small holder dairy farms. Artificial Insemination (AI) is one of such technologies that can solve these constraints if the necessary conditions are put in place to spur poor rural farmers to adopt the technology. This technology (AI) has been used for improvement of livestock production in developed countries. However, in developing countries, its use has been reported in several literatures to be less widespread and the result obtained are far from been satisfactory (Butswat and Choji, 1995). Under tropical small farm conditions, a number of socio-economic, organizational, biological and technical factors make the service more difficult to provide.

The conception rate in the field of AI programmes in developing countries is very low, and therefore the desired effect in terms of animal improvement has not been achieved. AI will become more effective only when farmers will have access to considerably better technical and organizational facilities (Verma *et al*, 2012).

In Ethiopia, even though AI is the most commonly used and valuable biotechnology that has been in operation for over 30 years in the country, the efficiency and impact of the operation has not been well-documented (Webb, 2003).

Generally, in developing countries including Ethiopia, a number of fundamental questions can now be asked about AI in livestock: To what extent is it being used today in developing countries? What are the reasons for its success (or failure) in developing countries? What emerging challenges can be addressed through its application (FAO International Technical Conference, 2010)?

Therefore, the objectives of this paper are: to address the above critical questions, to review the status of AI and major constraints influencing its efficiency in dairy cows in developing countries and finally forward relevant and workable recommendations for stakeholders and policy makers.

2. Definition

Artificial insemination (AI) is one of the earliest perfected technology where new breeds of animals are produced through the introduction of the male sperm from one superior male to the female reproductive tract without mating (Wilmut, 1979). It is a process by which sperm are collected from the male, processed, stored and artificially introduced into the female reproductive tract for the purpose of conception (Webb, 2003). Semen collected from the bull is deep-frozen and stored in a container with liquid nitrogen at a temperature of minus 196 degrees centigrade and made for use. AI has become one of the most important techniques ever devised for the genetic improvement of farm animals. It has been most widely used for breeding dairy cattle and has made bulls of high genetic merit available to all (Webb, 2003; Bearden *et al*., 2004).

3. History

As compared to other biotechnologies, AI is the most widely used both in developing and in developed countries. This technology has now become a practical technology in commercial dairy cattle programs in both developed and developing countries. Old Arabian documents dated around 1322 A.D. indicate that an Arab chieftain wanted to mate his prize mare to an outstanding stallion owned by an enemy. He introduced a wand of cotton into the mare's reproductive tract. Then he used it to sexually excite the stallion causing him to ejaculate. The semen was introduced into the mare resulting in conception (Webb, 1992). But, the first successful insemination was performed by Spallanzani (1784) in a bitch. Pioneering efforts to AI were begun in Russia in 1899 by Ivanoff (Ivanoff, 1922). Ivanoff had studied AI in domestic farm animals, dogs, foxes, rabbits, and poultry. Later on this technique was performed by various researchers worldwide in different species. Use of frozen semen (Polge *et al*., 1949) revolutionized the AI program through worldwide transport of semen. Globally, a large number of AIs are performed, more than 100 million cattle, 40 million pigs, 3.3 million sheep and 0.5 million goats are artificially inseminated every year (Boa-Amponsem and Minozzi, 2006).

Based on a survey of the situation in 1961 and 1962 by Nishikawa (1964) it was estimated that approximately 59 million cattle in the world were being artificially inseminated at that time. Of this world total, some 56 million were in Europe, North America, Oceania and Japan, leaving only about 3 million artificially inseminated cattle in the rest of the world. In another scenario, more than 100 million cattle were artificially inseminated every year (Boa- Amponsem and Minozzi, 2006).

In a world survey, Bonadonna (1972) received information from 52 countries, and these reported that more than 88 million cattle had been subjected to AI. Of these, Europe (including the USSR), the United States, Canada, New Zealand, Australia and Japan accounted for 73 million and the rest of the world for about 15 million. Bonadonna pointed out that his survey was incomplete and that there were several countries from which no information had been received. He estimated the total number of artificially inseminated cattle and buffaloes in the world to be more than 120 million a year.

Bonadonna's figures suggest that roughly 10 percent of the world's population of cattle and buffaloes were being subjected to artificial insemination by the end of the 1960s. However, there is great variation in the incidence of inseminated animals both between and within geographic regions. On the basis of the total populations of cattle and buffaloes, it may be estimated that about 30 percent are artificially inseminated in Europe, North America, Australia, New Zealand and Japan, while the corresponding figure for the rest of the world is around 4 percent. Only in a few developing countries does the incidence of cows served by AI exceed 1 percent of the total cow population. Notable exceptions are Cuba, where about 1.5 million cows (representing 50 percent of the country's dairy cows) are served, and Kenya; where about 500, 000 inseminations are recorded annually.

4. Is AI Common in Livestock Species Other Than Dairy Cows?

Although AI technology is available for other domestic livestock species, it is still most generally associated with dairy cattle. Its use in beef cattle has mainly been limited due to the difficulty in detecting those cattle that are in heat within large herds and where individual cows are handled only occasionally. With sheep and goats there is scope for improvement of the technology. The failure to develop a simple, non-surgical insemination procedure has prevented extensive exploitation of the technology in sheep (Robinson and McEvoy, 1993**;** de Haan & Setshwaelo, 2015). However, the technical success of laparoscopic intrauterine insemination has prompted research into less invasive transcervical procedures (Halbert *et al*, 1990; Buckrell *et al*, 1992). Generally, in most regions of the world, the use of AI is dominated by the cattle sector. In the Africa region in particular, few countries have extended the use of AI to other species (Pilling, 2007).

5. Status of AI in Developing Countries

No other technology in agriculture, except hybrid seed and fertilizer use, has been so widely adopted globally as AI (Gibson and Smith, 1989). In developing countries, AI is the most common technology used as compared to other biotechnologies probably due to that it has the most favorable cost-benefit ratio of the reproductive biotechnologies (Thibier *et al*., 2004) and also requires comparatively less technical skill and equipment.

There is no quantitative information on the current status of use of animal biotechnologies in developing countries except the use of some assisted reproductive biotechnologies such as AI, ET and molecular markers. The generation of the quantitative information on these biotechnologies was possible due to a painstaking and well organized study conducted by FAO, in which information on a country's capacity in the management of animal genetic resources for food and agriculture was gathered. Reports were received from 169 countries, submitted to FAO between 2002 and 2005 and presented in the State of the World's Animal Genetic Resources published in 2007 (FAO International Technical Conference, 2010).

According to FAO (2007), the following conclusions could be drawn about AI in respect of Africa, Asia, Latin America and the Caribbean.

AI is mostly used for cattle production systems, especially in the dairy sector. In Africa and Asia, its use is concentrated in peri-urban areas. Other species for which AI is used in all three regions are sheep, goats, horses and pigs, with use more common for sheep and pigs than goats and horses. In addition to these species, in Asia, AI is used for chickens, camels, buffaloes and ducks, and in Latin America and Caribbean regions, for rabbits, buffalo, donkeys, alpacas and turkeys. For the most part, semen for AI is from exotic breeds and used in the expectation of increasing the production of local livestock populations. To a lesser extent, semen from local breeds is also used for this purpose. In Côte d'Ivoire, semen from trypanotolerant cattle has been used and exotic semen has also been used for crossbreeding with naturally trypanotolerant cattle. Most of the AI services are provided by the public sector but the contribution of the private sector, breeding organizations and NGOs is also substantial (Table 1). Concerns have been raised regarding the loss of biodiversity due to inappropriate and poorly planned use of AI to inseminate locally-adapted cattle with imported semen for increased production. Most developing countries in Africa and Latin America do not have clear breeding policy in place.

Table1. Number of public and private sector organizations in Africa, Asia and Latin America and the Caribbean regions providing artificial insemination services (FAO, 2007).

	Africa[1]	Asia[2]	Latin America and Caribbean1
Public sector	26	17	11
Private sector	12	6	9
Breeding organizations	2	5	5
NGOs	8	4	NR
Universities	2	1	NR

Where, NR=not reported

[1] Countries providing information on service providers: Africa, 26; Asia, 17; Latin America and Caribbean, 11.

The country reports also indicate that nations such as Bhutan, the Democratic Republic of the Congo, Gambia, Guinea and Laos wish to initiate AI activities but need to build the necessary infrastructure and capability required for initiating a sustainable programme. Cape Verde, Chad, the Cook Islands, Ghana and Sudan all reported having started AI in the past but having stopped due to financial constraints. So, the AI infrastructure has subsequently deteriorated in these countries (Boa-Amponsem and Minozzi, 2006).

6. The Need for Artificial Insemination

Rozeboom (2007) suggested that among all the fundamental systems of animal breeding exercise such as random mating, in-breeding, line breeding and out breeding, artificial insemination has proved to be the best and efficient method. According to Butswat and Choji (1995), AI is a vital tool for the rapid improvement of livestock allowing for maximum use of best sires on numerous dams and that it is one of the animal production techniques which can augment production and returns from livestock at a faster rate through cross-breeding programme. AI also credited for providing the impetus for many other developments which have had a profound impact on reproductive biotechnology. For example, studies of oestrus detection and ovulation control which evolved out of a need to correct timely inseminations, led to the development of embryo-transfer technology (Foote, 1982).

Compared with natural mating, AI has been used for genetic improvement by utilizing proven sires, decreasing risk of venereal disease transmission, maintaining accurate breeding records necessary for good herd management, economic service, culling dangerous males on the farm, avoiding injury during mating, avoiding utilizing semen of incapacitated bulls (Hafez, 1993; Roberts, 1986; Rodring, 2000). Furthermore, AI is helpful in lessening the need of farms to maintain breeding males and minimizing the cost of introducing improved genetics (Wilmut, 1979). All in all, even though there are some drawbacks, they have been overweighed by the advantages (Roberts, 1986).

6.1. Reducing transmission of diseases through sexual contact

Exposure of sires to infectious genital diseases is prevented by use of AI which reduces the danger of spreading such diseases (Webb, 1992). In other way, if only males known to be free from disease are selected for semen collection, artificial insemination can play an important part in controlling diseases spread through sexual contact. Among the diseases in this group are granular vaginitis, trichomoniasis, navel ill, dourine, brucellosis and coital exanthema. Despite the role of artificial insemination in preventing the spread of a disease from one female to another through the male or from the female to the male during natural mating, it may however be the means of spreading diseases if improperly practiced. Most cooperatives obtain the services of a veterinarian for this work, which requires not only knowledge of the symptoms of diseases but recognition of the necessity for cleanliness, sanitation, and the proper disinfection of utensils before and after use (Frank and Ralph, 1942).

During natural mating, diseases may be transmitted from the male to the female either mechanically, by carrying the infective organisms from one female to another during mating, or as a result of infection in the reproductive organs and this is prevented by using AI. However, semen samples collected from the male in the artificial vagina are subject to contamination with germs or bacteria, just as is milk drawn from the udder. Bacteria in semen may come either from the reproductive organs of the male or from the apparatus used for collection. By such measures as the provision of sanitary surroundings, regular grooming and the use of sterile apparatus for collecting, the bacteria in semen from healthy males can be kept down to very low number and under such circumstances most types of bacteria do not materially affect fertilizing and keeping qualities(Frank and Ralph, 1942).

6.2. Improving animals' productivity

AI plays an important role in enhancing animal productivity, especially milk yields, in developing countries that have a well-defined breeding strategy and a sound technical base to absorb and adapt the technology to meet their needs (BBC, 2015). Daughters of AI sires produce significantly more milk than those of herd bulls sires and the income from this extra milk may cover the extra costs resulting from extended calving intervals because of low heat detection. A study indicated that daughters of AI sires were producing almost 900 kg of extra milk per lactation than daughters of natural service bulls (Valergakis *et al*, 2007). Another report from USA showed a difference of more than 1000 kg of milk per lactation on farms using AI (Smith *et al.,* 2005; Zwald, 2003). This means that farming using AI can be more profitable apart from covering the extra costs even with calving interval of 13.5-14 months (Valergakis *et al*, 2007).

For countries to increase their dairy cow productivity, they have to maintain successful AI systems with: 1) an effective technology transfer mechanism; 2) effectively integrated international assistance into their national germplasm improvement programmes; 3) building and maintaining infrastructure; 4) complement with improvements in animal nutrition and veterinary services; and 5) adequate economic incentives to market dairy products. However, many developing countries lack one or more of these requirements (Heifer International, 2014).

6.3. Harvesting of individual sires with traits of superior quality

The greatest advantage of AI is that it makes possible maximum use of superior sires (Webb, 1992) in which desirable characteristics of a bull or other male livestock animal can be passed on more quickly and to more progeny than if that animal is mated with females in a natural fashion (Milad, 2011). Natural service would probably limit the use of one bull to less than 100 matings per year. In 1968, AI usage enabled one dairy sire to provide semen for more than 60,000 services (Webb, 1992). In another record, progress in semen collection and dilution and cryopreservation techniques enabled a single bull to be used simultaneously in several countries for up to 100,000 inseminations a year (Gibson and Smith, 1989). This implies that a very small number of top bulls can be used to serve a large cattle population. In addition, each bull is able to produce a large number of daughters in a given time, thus, enhancing the efficiency of progeny testing of bulls. The high intensity and accuracy of selection arising from AI can lead to a four-fold increase in the rate of genetic improvement in dairy cattle relative to that from natural mating (Van Vleck, 1981). So, AI has become one of the most important and successful reproductive biotechnology ever devised for the genetic improvement of farm animals. It has been most widely used for breeding dairy cattle and has made bulls of high genetic merit available to all (Webb, 1992;

Mukasa-Mugerwa, 1989).

7. Constraints and Limitations of AI

7.1. Cost of AI compared to natural service

Despite the well-known advantages of artificial insemination, a large number of dairy farmers all over the world still use natural service (NS) bulls to breed their cows. The main arguments allegedly justifying their choice are higher AI costs compared to those of keeping herd bulls and additional costs resulting from extended calving intervals because of low heat detection rates when AI is used. AI costs include; labor, equipment, liquid nitrogen, semen and three ratios of "services per conception" (Valergakis *et al*, 2007). The availability of economically priced liquid nitrogen for the cryopreservation of semen is also a particular constraint to utilize AI as a whole (FAO International Technical Conference, 2010).

7.2. Impact of AI in genetic diversity

Eventhough AI is highly effective in improving animals' productivity, there is also a concern that its inappropriate or unplanned use can lead to increased rates of genetic erosion and breed extinction (Pilling *et al*., 2007). The heavy use of the best males results in a strong increase in inbreeding and a lose of genetic diversity. In a study in USA, the annual increase in the inbreeding trend in Holstein dairy cows was estimated to be near to 0.5% (Wiggans *et al*., 2000)! An example Holstein bull Skalsumer Sunny Boy that had been used at least for over 1,000,000 first inseminations, showed the risks of rapidly shrinking breeding populations. Another research in France (Maigel *et al*., 1996) showed that the local Holstein population with over 5 million animals was in reality behaving as if this population consisted of less than 100 unrelated animals!

7.3. Difficulty of heat detection

Among different factors that can affect conception rate per AI service, accuracy of heat (estrus) detection is the major one that determines AI program since ova remains viable for only about 12-18 hours after ovulation (Bekana, 1991; Rodriguez-Martinez, 2000). A successful AI program must include efficient and accurate heat detection and timely AI relative to ovulation. The failure to detect heat is the most common and costly problem of AI programs and the major limiting factor of reproductive performance on many dairies (Nebel and Jobst, 1998; Dalton, 2011). The physiological relationship linking ovulation to the onset of standing activity underscores the importance of accurate heat detection as there is a limited window of opportunity in which to maximize conception to AI. Many biological events occur within the limited window of opportunity (Figure 1), including: the transport time required for viable sperm from the site of deposition to the site of fertilization, the functional viable lifespan of sperm and ova and the timing of ovulation in relation to AI (Dalton, 2011).

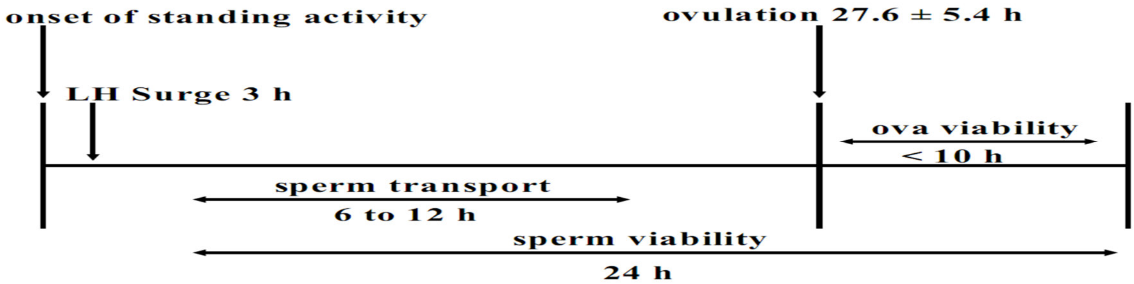

Figure1. Biological events contributing to the optimization of AI (Dalton, 2011).

8. Status of AI in Ethiopia

Ethiopia owns the largest livestock population in Africa (Lemma and Kebede, 2011) but its contribution to the overall production has shown low productivity as compared to the potential (Kumar, 2005). The dairy industry in is particular not developed like other East African countries (Lemma and Kebede, 2011). This may be due to their low genetic potential for specific product or enough knowledge is not available on the indigenous breeds (Kumar, 2005). But, even with very few crossbreds (0.5%) and pure exotics breeds (0.1%), dairy production has been becoming an essential component of the agricultural sector contributing to the alleviation of malnourishment through the production of milk and milk by-products in Ethiopia (Azage, 2000; Lobago, 2006).

An achievement in increasing milk and meat production by improving the genetic merit of indigenous cattle has been one of the primary livestock development objectives of Ethiopia (Heinonen, 1989). Improvement in livestock resources have been achieved through the implementation of an efficient and reliable AI service, in parallel with proper feeding, health care, and management of livestock (Meles and Heinonen, 1991). The country has made great effort to improve the productivity of local breeds through AI program to crossbreed locally adapted cattle breeds with improved exotic dairy breed ones. This program has been addressing major parts of the country including Amhara and SNNPR regions. Nevertheless, the success of such programs has not been satisfactory due to numerous factors, including substandard nutrition, poor husbandry practice and infrastructure status Thus, dairy producers have challenging complaint about a poor reproductive performance in animals using AI (Lemma and Kebede 2011). As a result, dairy production is at its lowest stage compared to other countries (Azage, 2000; Lobago, 2006).

Historically, Artificial insemination (AI) as one option to improve the genetic potential of the indigenous breeds of cattle has been introduced to Ethiopia in the early 1930's, but it was interrupted by World War II (Brannang, 1980) and restarted in 1952 (Yemane *et al.*, 1993). It was again discontinued due to unaffordable expenses of importing semen, liquid nitrogen and other related inputs requirement (Zewdie *et al.*, 2006). However, it was introduced at a wider scope in the late 1960's (Brannang, 1980) and cross breeding through AI was considered as the most suitable economical and time tested breeding technique for generating the higher genetically potential and productive animals (Naokes, 2001). In 1984, National Artificial Insemination Center (NAIC) has been established to coordinate the overall AI operation throughout the country (NAIC, 1995; GebreMedhin, 2005). As a result of this, urban dairying is flourishing in many small towns and big cities with different level of intensification from less than 1% to over 40% growth (Kelay, 2002).

Eventhough it is the most commonly used and valuable biotechnology that has been in operation in Ethiopia for over 30 years with different levels of intensification , the efficiency and impact of the operation has not been well-documented (Webb, 2003). Furthermore, according to Sinishaw's report (2005), it is widely believed that the AI service in the country has not been successful to improve reproductive performance of dairy industry. From the previous little study, AI service is weak and even declining due to inconsistent service in the small holder livestock production system of the Ethiopian highlands (Gebremedhin, 2005).

Because of inefficiency in AI services and consequently reproductive inefficiency, there has been a wide belief among dairy producers that dairy animals perform better when bulls are used than AI. Moreover, there is a challenging complaint about a poor reproductive performance in animals using AI than natural service (NS). This, contrary to the dairy development plan, is hampering the use of AI to upgrade the production and dairy producers are becoming increasingly skeptic of the use of AI (Binici, 2006).

8.1. Major factors affecting efficiency of AI in Ethiopia

The efficiency of AI in the country has remained at a very low level due to many constraints including; infrastructural, managerial and financial constraints and also due to technical problems such as; poor heat detection, improper timing of insemination and embryonic death. The artificial insemination program in rural bovines is greatly influenced by the status of the farmer's i.e. large marginal, small, and land less farmers (Kumar, 2005). In addition, conception rate per AI service is affected by; cow related factors including cow fertility, body condition, environmental stresses, bull fertility/ quality of semen, efficiency of AI techniques, skills of the inseminators, care of the semen collected, processed and stored etc (Nichlson and Butherworth, 1986; Ntombizakhe, 2002; Rogers, 2001). The risk of all these factors vary as the type of production system, level of the dairy business and even with agro ecology (Hafez, 1993; Franklin, 2003; Smith, 1982). The problem is more aggravated by wrong selection and management of AI bulls along with poor motivation and skills of inseminators (Gebremedhin, 2005).

Unlike farms using AI, farms using NS have a better chance of detecting estrus and getting heifers or cows pregnant at the first opportunity. Farms using AI have to go through the difficulties of estrus detection required for proper insemination which are both the number one problems in the success of AI in Ethiopia. Moreover, a number of previous works confirmed that management factor especially nutrition determines prepubertal growth rates and reproductive development have their own impact on AI. The better managed and well-fed heifers grew faster, serve earlier and result in more economic benefit in terms of sales of pregnant heifers and/or more milk and calves during the life time of the animal (Lobago, 2006; Masama, 2003).

Eventhough, smaller farms often rely on AI service because of the cost or difficulty of keeping a breeding bull for natural insemination (Lemma and Kebede, 2011; Rocha, 2001; Kelay, 2002), several factors associated with the success of AI particularly detection of heat, efficiency of inseminator, communication and transport problems and quality of the semen have contradictory effect (Rocha, 2001; Kelay, 2002). Problems with estrous detection as one of constraints become more important in affecting the reproductive performance of dairy cows as herd size increases (Smith, 2004). As also reported in a study (Kelay, 2002), accessing an AI service has many technical and logistic hurdles contributing to the failure of the timely service of estrous cows hence results in poor reproductive performance. So, many dairy farmers use NS to overcome problems associated with estrous detection (Risco, 2000).

9. Conclusion and Recommendations

By way of conclusion, after a hiatus following its introduction, Artificial insemination is receiving renewed attention in dairy cows recently. AI technology maximizes animals' productivity and harvests individual sires with traits of superior quality through: the use of outstanding males, disseminating superior genetic material, improvement of the rate and efficiency of genetic selection, introducing new genetic material by import of semen rather than live animals and enables the use of frozen semen even after the donor is dead. It also reduces the risks of spreading sexually transmitted diseases. In several developing countries in particular, in spite of the efforts made to introduce large-scale AI breeding services, growth in its use has generally not been very strong and conception rate is very low. Therefore, the desired effect in terms of animal improvement has not been achieved. The reasons behind are inefficient heat detection, lack of proper management and technical skill. Many dairy farmers incline to use NS than AI because of fear of loss due to poor heat detection.

Based on the above conclusion, it would be reasonable to forward the following recommendations.

- Regular training should be given to animal owners and AI technicians about technical and organizational facilities for AI.
- Economic incentives should be provided to farmers to breed improved animals for the successful introduction or extension of AI in developing countries.
- Governments have to design and implement clear policies for AI through alleviating the most important causes of failure.
- Furthermore, sound long-term breeding strategies that would improve the farmers' profits in the short term without destroying the indigenous genetic resources in the long term should be supplemented.
- Oestrus synchronization has to be introduced as a means of resolving oestrus detection problems.
- Further researches to create awareness for the society have to be conducted and forwarded.

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